

Meteorite Dust and Health – A Novel Approach for Determining Bulk Compositions for Toxicological Assessments of Precious Materials

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Introduction: With the resurgence of human curiosity to explore planetary bodies beyond our own, comes the possibility of health risks associated with the materials covering the surface of these planetary bodies. In order to mitigate these health risks and prepare ourselves for the eventuality of sending humans to other planetary bodies, toxicological evaluations of extraterrestrial materials is imperative (Harrington et al. 2017). Given our close proximity, as well as our increased datasets from various missions (e.g., Apollo, Mars Exploration Rovers, Dawn, etc...), the three most likely candidates for initial human surface exploration are the Moon, Mars, and asteroid 4Vesta. Seven samples, including lunar mare basalt NWA 4734, lunar regolith breccia NWA 7611, martian basalt Tissint, martian regolith breccia NWA 7034, a vestian basalt Berthoud, a vestian regolith breccia NWA 2060, and a terrestrial mid-ocean ridge basalt, were examined for bulk chemistry, mineralogy, geochemical reactivity, and inflammatory potential. In this study, we have taken aliquots from these samples, both the fresh samples and those that underwent iron leaching (Tissint, NWA 7034, NWA 4734, MORB), and performed low pressure, high temperature melting experiments to determine the bulk composition of the materials that were previously examined.

Methods: Prior to our experimentation, toxicological evaluation of all samples were performed and the results can be found in Harrington et al. (2017). In order to determine the bulk composition of the materials used to assess for pulmonary inflammatory responses to acute meteorite dust exposures, experiments were conducted at a pressure of ~0.75 GPa in the 13 mm quickpress piston cylinder housed at Johnson Space Center (JSC). Materials of both the fresh and leached components, when available, were loaded into graphite capsules with press-fit lids. Each loaded capsule was placed within a graphite furnace with crushable MgO parts, and the graphite furnace resided within a BaCO₃ cell, which was used as a pressure medium. Samples were first pressurized to ~0.75 GPa and then heated to the desired temperature using Type C (W₅Re/W₂₆Re) thermocouple wires to monitor the temperature and a Eurotherm (2416) controller to control and monitor temperature throughout the duration of each run. All experiments were heated to temperatures greater than 1600 °C to ensure melting of the starting compositions and homogenization of the meteorite materials. After being held at elevated pressure and temperature for 25 minutes to 2 hours, depending on the stability of the run, each experiment was isobarically quenched by shutting off power to the furnace and maintaining the pressure of the assembly at ~0.75 GPa. Once the charge had been isobarically quenched, the experiment was slowly decompressed and mounted in epoxy and polished to a 0.3 µm finish for subsequent analysis.

Electron probe microanalysis of all phases will be carried out using a JEOL 8530F electron microprobe, at JSC. All phases will be analyzed using an accelerating voltage of 15 keV and a beam current of 15 nA. A broad beam (10–20 µm) will be used for glass analyses and a focused beam (1–5 µm) will be used if any minerals are present. Standards will include augite (for Si, Al, Ca, Mg), titanite (Ti), almandine (Al, Fe), pyrope (Cr, Mg, Ca), spessartine (Mn), olivine (Mg, Si, Fe), and albite (Na) to analyze our quenched melt and any minerals. Prior to analyses, all samples

will be examined using Energy Dispersive Spectrometry and all additional elements that are detected will be included in routine microprobe analyses. Peak count times will range from 30–60 seconds and background count times will range from 15–30 seconds, respectively.

Discussion: The bulk composition of meteorite samples are extremely important in the Earth and Planetary Sciences. From meteorite studies we are able to place constraints on large scale planetary processes like global differentiation and subsequent volcanism, as well as smaller scale processes like crystallization in a magma chamber or sedimentary compaction at the surface. However, with meteorite samples in particular, far too often we are limited by how precious the sample is as well as its limited mass. With this technique, only ~50 mg of sample is required to accurately determine the bulk composition of the materials of interest.

References: Harrington, A.D., McCubbin, F.M., Kaur, J., Smirnov, A., Galdanes, K., Schoonen, M.A.A., Chen, L.C., Tsirka, S.E., and Gordon, T. (2017) Pulmonary inflammatory responses to acute meteorite dust exposures – Implications for human space exploration. 48th Lunar and Planetary Science Conference, The Woodlands, TX, #2922.